7-2-2020

Textile Dispenser

Sabrina Nguyen
Washington University in St. Louis

Syeda Mohsin
Washington University in St. Louis

Textile Dispenser: MEMS 400

Background and Motivation

A. Objective of textile repurposing

Dr. Ruppert-Stroescu, a professor at the Sam Fox School of Design and Visual Arts at Washington University in Saint Louis, has been working on a project that aims to eliminate textile waste and inspire sustainability in the fast fashion industry. Currently, her upcycling process consists of cutting used fabric into strips, pasting them down into creative designs onto a dissolvable material, and sewing the pieces together to create an entirely different piece of clothing. Ultimately, her purpose is to be more environmentally friendly as well as more innovative with her designs and methods.

B. The textile dispenser's contribution to Dr. Ruppert-Stroescu's process

The textile dispenser would be an integral part of her mission. As engineers, we want to optimize her process and eliminate any arduous, laborious tasks by building a handy tool that could be scaled up using technology. Currently, Dr. Ruppert-Stroescu spends a lot of time manually cutting pieces of fabric and laying down and pasting the pieces onto a dissolvable interface by herself. She needs a method that is more ergonomically friendly and time efficient than her current process. Because her current process is laborious and can cause strain to her hands after long periods of time, it is also vital to design a tool that will be comfortable for the user and help them accomplish the tedious laying and pasting processes. The textile dispenser aims to intake fabric strips that are wrapped around a telescoping cylinder and dispense them parallel to one another onto the dissolvable interface.

Previous Models

C. MEMS 411 Design Process and Original Performance Goals

Our previous design in MEMS 411 used a design with rollers, and acrylic base, and a cylinder that rolled and dispensed out the fabric.

Our performance goals were as follows.

A. T-shirt strip dispenser lays down 5 2-foot strips of t-shirt in less than 1 minute.

B. TSD performs this test with all strips well adhered (resists gentle tugging along strip)

C. User can replace spool and replenish adhesive within 40 seconds.

Our end of the semester prototype was a bulky design involving a roller to facilitate the fabric dispensing, two caster wheels, a spool made of two 3-D printed telescoping cylinders, a circular holder for the roll of tape, and a laser-cut acrylic platform. A drawing of our prototype is shown below in Figure 1.

D. End-of-Semester Prototype (MEMS 411)

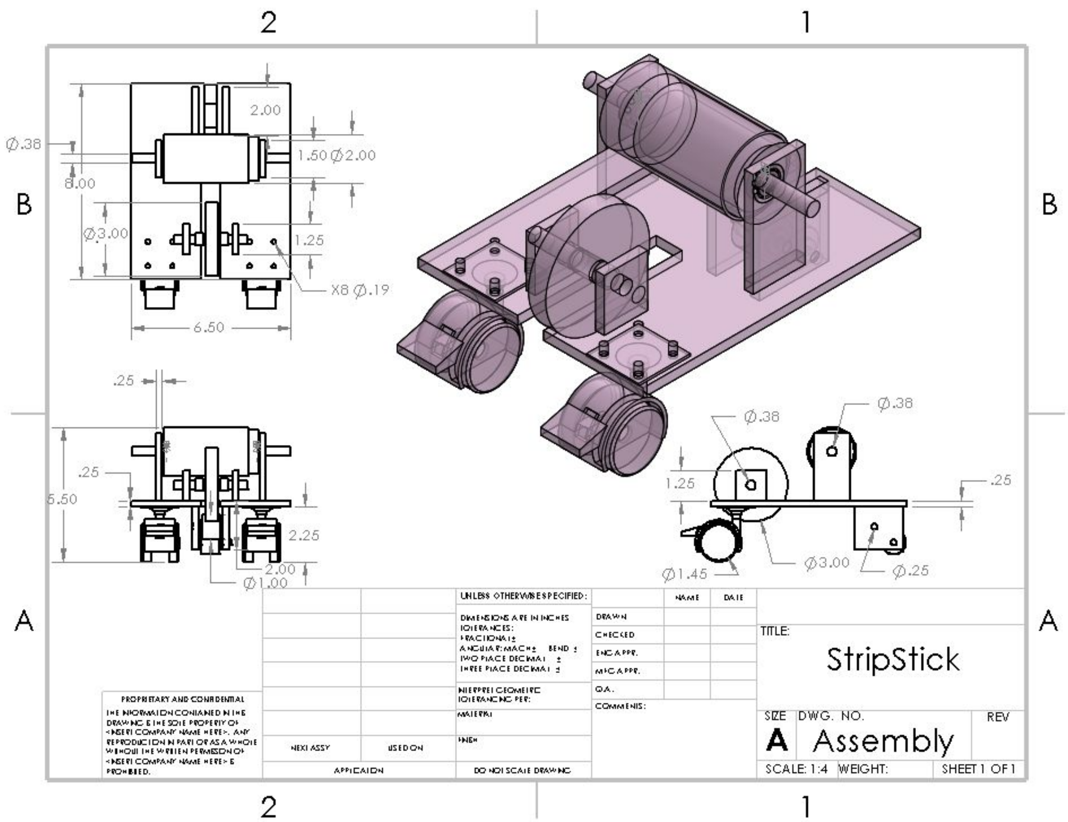
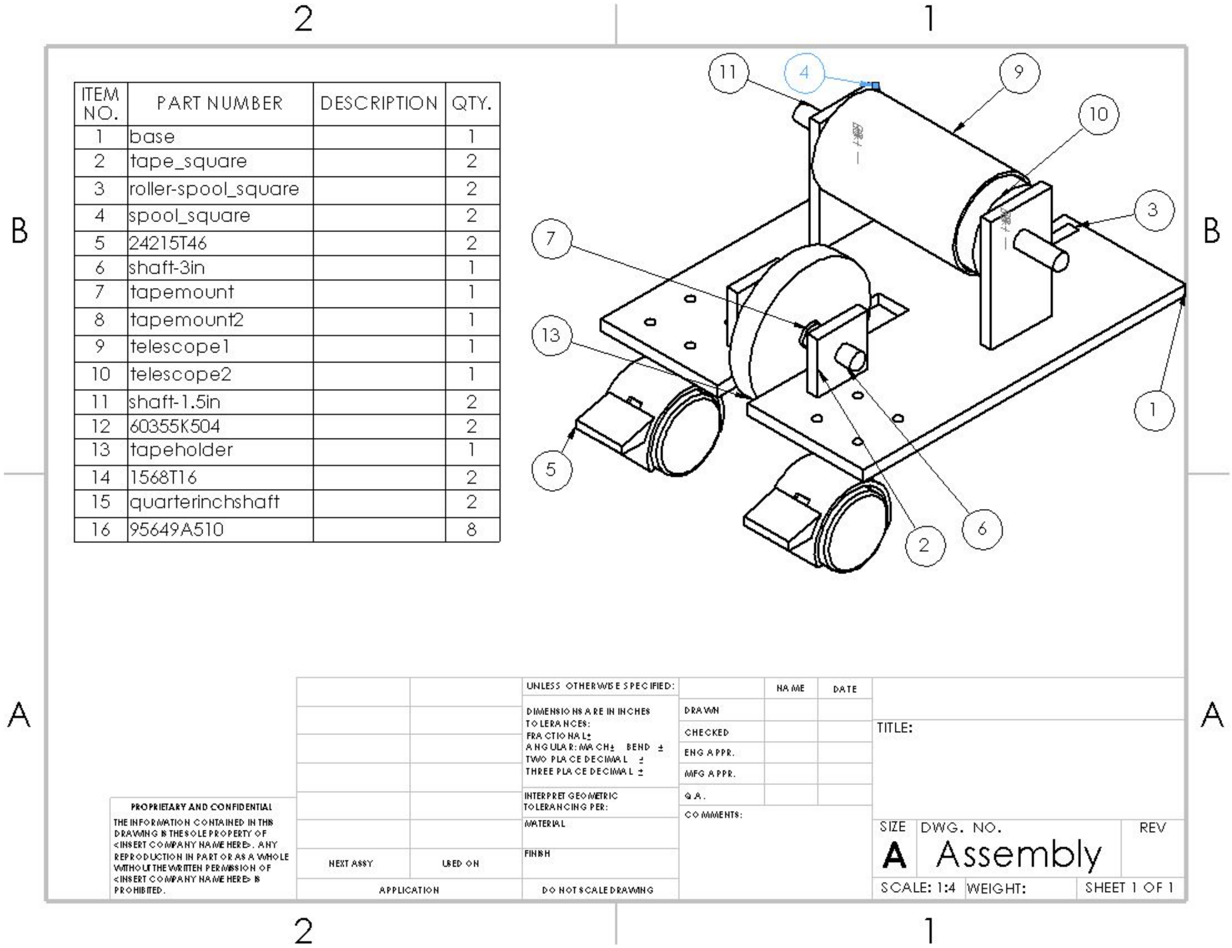


Figure 1: Assembly Drawing of Final Prototype

The assembly drawing with the bill of materials is shown below, in Figure 2. .



ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1	base		1
2	tape_square		2
3	roller-spool_square		2
4	spool_square		2
5	24215T46		2
6	shaft-3in		1
7	tapemount		1
8	tapemount2		1
9	telescope1		1
10	telescope2		1
11	shaft-1.5in		2
12	60355K504		2
13	tapeholder		1
14	1568T16		2
15	quarterinchshaft		2
16	95649A510		8

Figure 2: Assembly Drawing of Final Prototype with BOM

The end of semester prototype did not guide the fabric in a straight line and did not have a cutting mechanism or a gluing mechanism. It also was not an ergonomically friendly design; the cloth did not smoothly dispense through the rollers and sometimes got caught. Below, in Figures 3-5, is the wooden iteration of our final prototype. We recreated the product using acrylic, but the wooden model was made at the end of our time officially working on this project. In Figure 3, we see a side view of the wooden prototype.

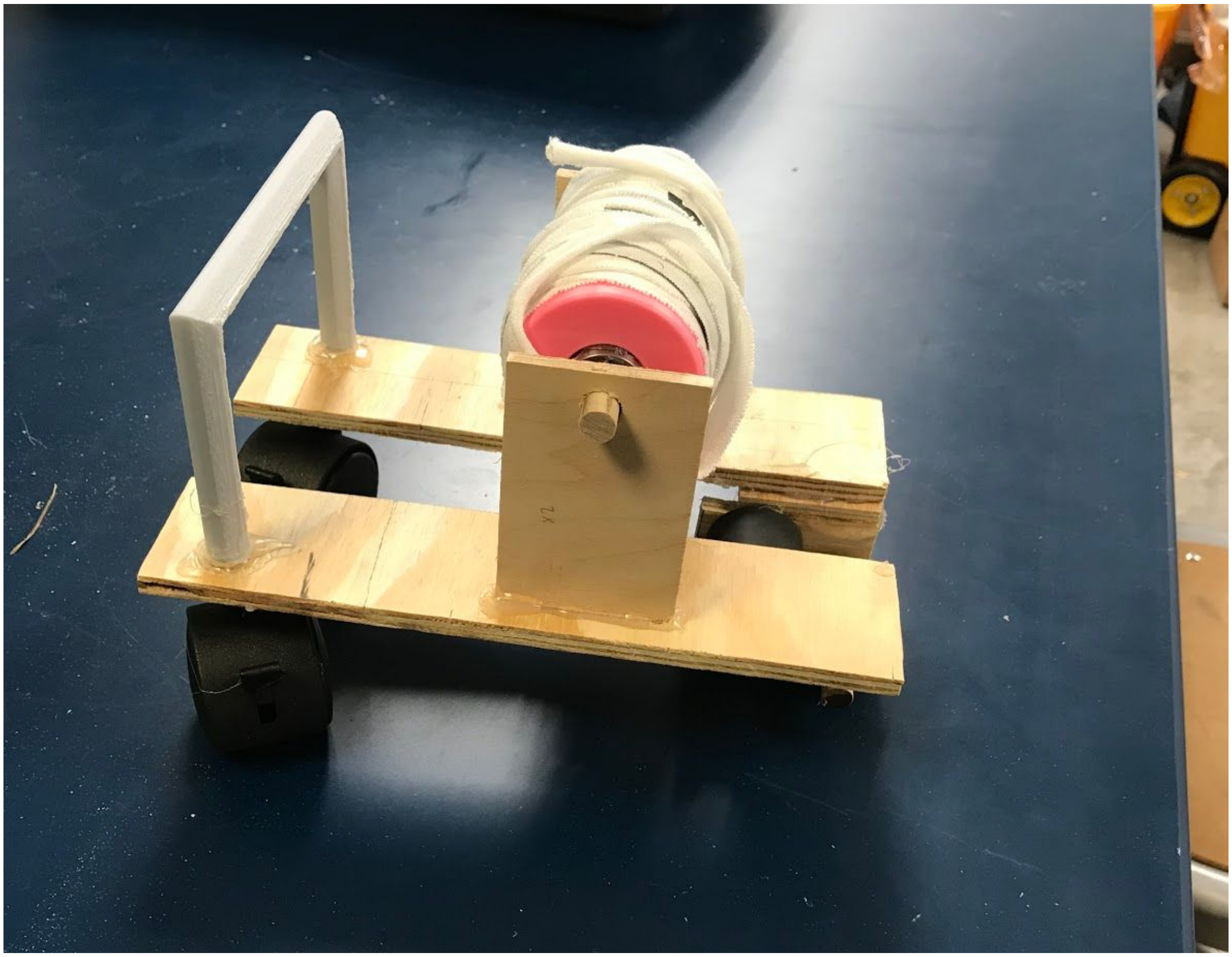


Figure 3: Side View of Final Prototype

In Figure 4 below, we see a bottom view of the final prototype, showcasing the types of rollers and wheels that were used.

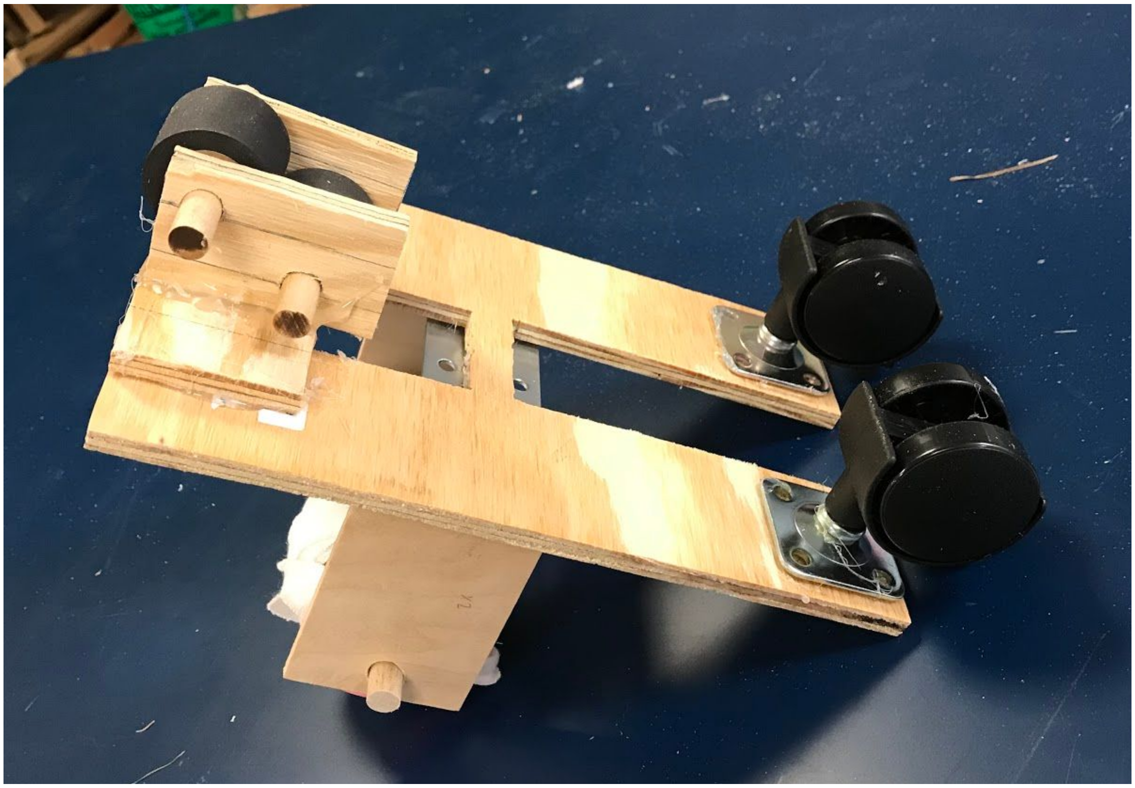


Figure 4: Bottom View of Final Prototype

In Figure 5 below, we see the top view of the final prototype, highlighting the spool and the ½ cloth wrapped around it.

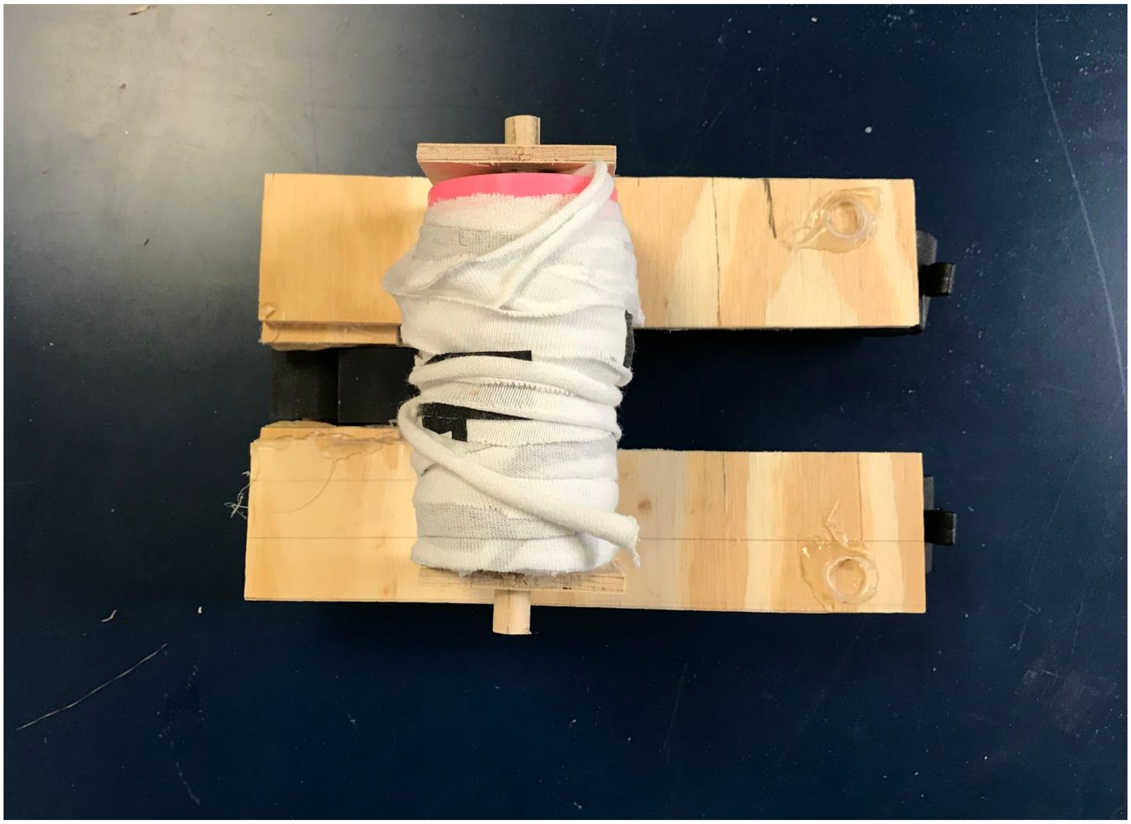


Figure 5: Top View of Final Prototype

Revised Performance Goals

Need for More Information

In MEMS 411, our focus was on producing a product that was sustainable and improved the overall laying process of the fabric. One of the biggest pain points of Mary's process was working with cotton fabric strips that easily curled due to tension. This problem inspired the use of rollers in the dispensing process. To improve the sustainability of Mary's process, we switched out the aerosol adhesive spray with double-sided biodegradable, dissolvable fabric tape. Before laying down the strips of fabric, Mary would need to lay down the strips of tape onto the dissolvable paper. As for our performance goals, we were able to lay down and adhere five two-foot strips of fabric in less than one minute. We also used a typical toilet paper dispensing mechanism involving two telescoping cylinders to facilitate the replacement of the spool of fabric within forty seconds. A diagram of the telescoping cylinders is shown below, in Figure 6.

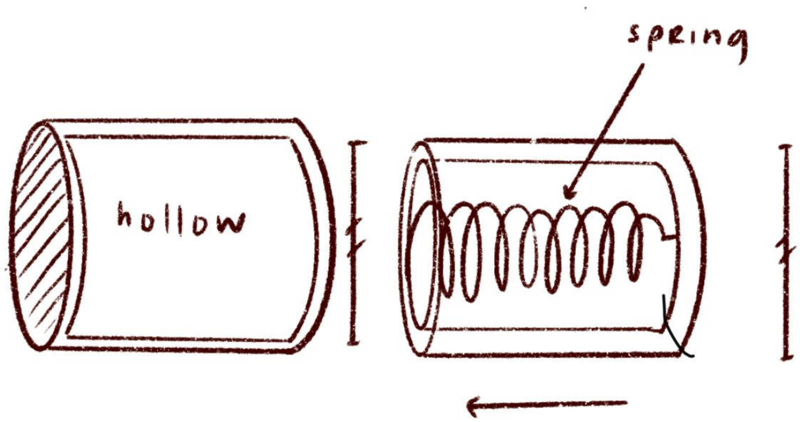


Figure 6: Telescoping Cylinders

While we successfully met the performance goals from MEMS 411, the final product had left much to be desired. The device was not easy to use nor was it practical—the dispensing of the fabric was difficult to maneuver in straight lines, the product was too bulky, and the dispensing process caused too much tension on the fabric. Based on the pain points of our last prototype, we wanted to focus on improving the usability, practicality, and efficiency of the product. As such, we met with Mary again to gather more insights into what she envisions for an ideal product through conducting a contextual interview.

Second Interview with Prof. Ruppert-Stroescu

In our initial interview during MEMS 411, we had an introduction to Mary's current process and the time it took to complete each task. The cutting and laying process generally took one hour total. Cutting one t-shirt into one inch strips took nearly 15 minutes. Laying 25 strips per t-shirt would take more than six minutes. To make a skirt, the cutting and laying process would take 3 or 4 hours, with 3.5 hours dedicated to the laying process. Mary also expressed her frustration with how the laying process was messy — the aerosol adhesive she used and having to lay down the fabric strips manually made her hands dirty. Due to the painstaking laying process, we chose to focus primarily on improving it so that it was cleaner, more sustainable, and took less time.

In our most recent interview with Mary, we conducted a comprehensive contextual interview to witness first-hand the tedious process of laying and adhering the strips of fabric down onto the biodegradable material. This gave us an opportunity to discuss with her potential solutions that might relieve those issues. Some ideas that were tossed around were creating a motorized version of our most recent prototype, building a motorized CNC board that would automatically lay down strips of fabric via a shuttle moving along rails, and ways to improve the roller dispensing mechanism. We also discussed with her the negative environmental impact of aerosol and presented our solution, which was the use of double sided, biodegradable and dissolvable tape. When discussing the problems with curling fabric due to tension, Mary provided a broad survey of different fabrics and their behaviors when undergoing tension.

Prof. Ruppert-Stroescu's Current Step-by-Step Process

When watching her process, which involved spraying the aerosol adhesive, laying down strips onto biodegradable paper, and sewing the fabric to the dissolvable paper, we gained new insights into her biggest user need — a device that could be scaled up. While building a CNC assistance machine would be the most intuitive route, it would exceed the scope of our project. Through learning her process firsthand, we were able to build a list of new performance goals to guide our design process. The steps Mary took to create a 10 inch x 7 inch rectangle of a layer of fabric strips is listed below. This process took approximately 20 minutes.

Laying of Fabric:

1. Pin down a 10 inch x 7 inch rectangle of biodegradable paper to a thick mat of cloth as shown below in Figure 7.

Figure 7: Pinning Down Biodegradable Paper

2. Spray aerosol adhesive onto biodegradable paper. The type of adhesive she currently uses is shown below in Figure 8.

Figure 8: Aerosol Spray

3. Starting at one end of the rectangle of the longer side, lay down strips of fabric onto biodegradable paper, overlapping fabric strips onto adjacent strips by ⅛ inch, and cutting the strip at the end of the square. Each strip took 6 seconds to lay down and cut, and her process is shown in a still, in Figure 9.

Figure 9: Adhering Strips of Fabric

4. Spray more adhesive onto the layer of fabric strips.
5. Lay down and adhere another 10 inch x 7 inch rectangle of biodegradable paper onto the layer of fabric strips. Usually Mary would add another layer of fabric onto the opposite side of the biodegradable paper.

Sewing the Pattern:

1. Sew the fabric sandwiched by biodegradable paper in any pattern, as she is doing below in Figure 10.

Figure 10: Sewing Pattern

Dissolving the Paper

1. Once the fabrics are secured, dissolve the biodegradable paper by running the sewn piece under water, as we see her demonstrating in Figure 11.

Figure 11: Dissolving Biodegradable Paper

New Performance Goals

We developed an updated set of performance goals that would improve the speed at which the fabric dispenses and the usability of the product are listed as follows.

1. Lay down and adhere 5 2-foot strips of fabric in 30 seconds
2. TSD performs goal 1 with strips well adhered, without tension, and on a straight path
3. Replace spool with new spool within 10 seconds

Revised Design Concepts

Existing Technologies

A current model we are looking into is that of a tile cutter. Below, in Figure 12 is a rough sketch on what we are reimagining our tool to do.

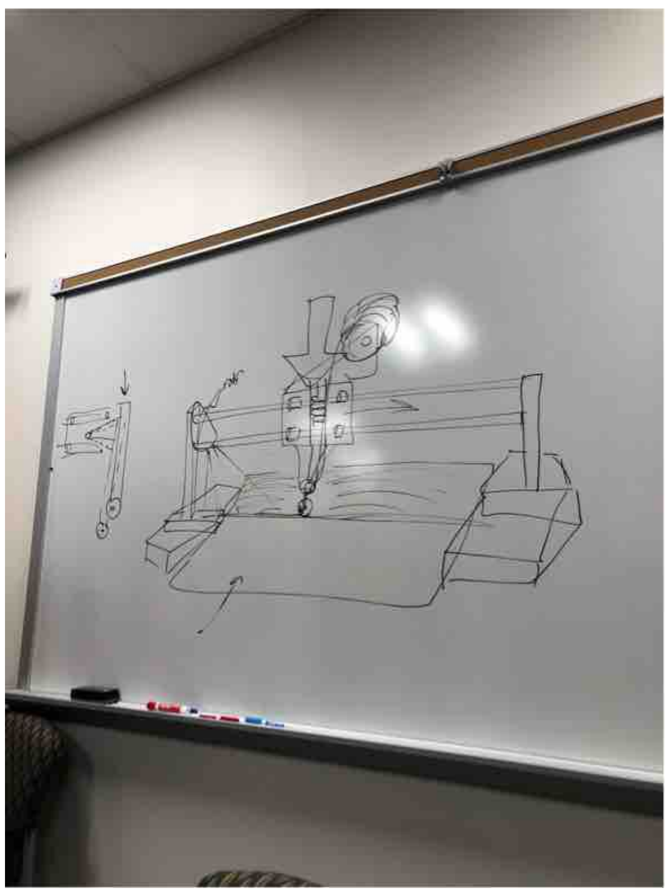


Figure 12: Reimagined Design of Tile Cutter Design

The tile cutter model would involve all the parts of a typical tile cutter, except there would be a shuttle with rollers sliding along the metal rails to lay down the strips of fabric laterally. This would be a more ergonomically friendly design since everything is on one platform. It would be also easier to potentially add a cutting mechanism at either end of the rails. This design would eliminate a lot of the pulling required by the user as it would require the user to slide the shuttle along the bars without having to add tension or force on their own onto the tool, as had to be done in the MEMS 411 design. Below in Figure 13, is the exact tile cutter we used for our study.

Figure 13: The Tile Cutter Used in our Study [1]

Another possible design would be something modeled after a CNC machine. The user would be able to code a pattern into the machine and have the resulting pattern laid down onto the dissolvable material. It would follow a similar design, in that a bar with a dispenser would move laterally to cover the outline of the coded pattern. This design would require a motor and code to guide the tool. An example of what a CNC tool would look like is shown below in Figure 14.

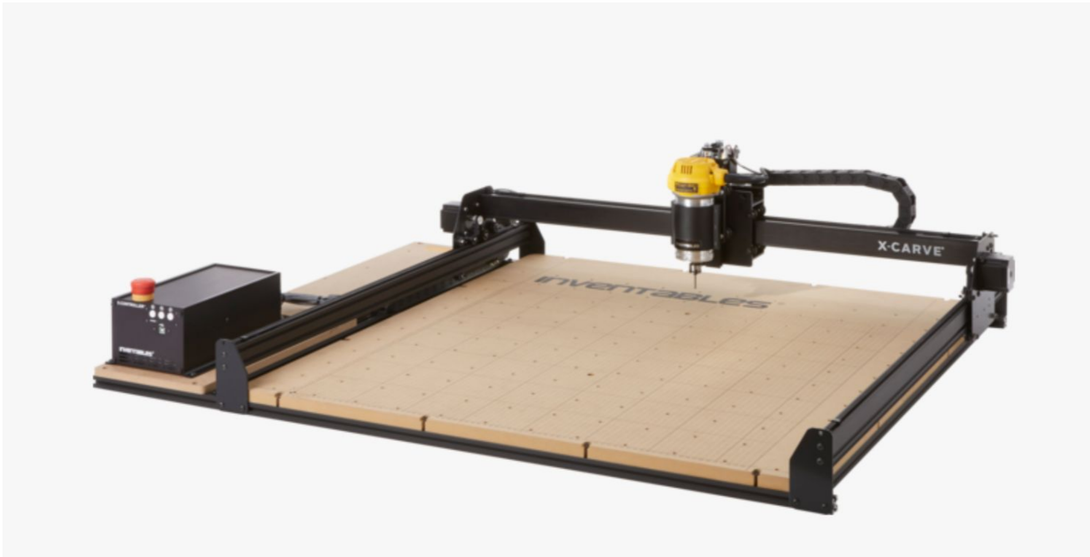


Figure 14: Example CNC tool, Inventables [2]

Concept Embodiment for Design Ideas

Tile Cutter Model

The first variation of our design is similar to that of a manual tile cutter. A moving base which attaches to the removable spool and roller can move laterally along the rods attached to the main base. The user would need to manually align their fabric mat with the biodegradable paper before laying down the fabric. The fabric from the spool would feed through the rollers as the user pulls backward via the extension of the moving base. A rough sketch of this variation is shown below, in Figure 15.

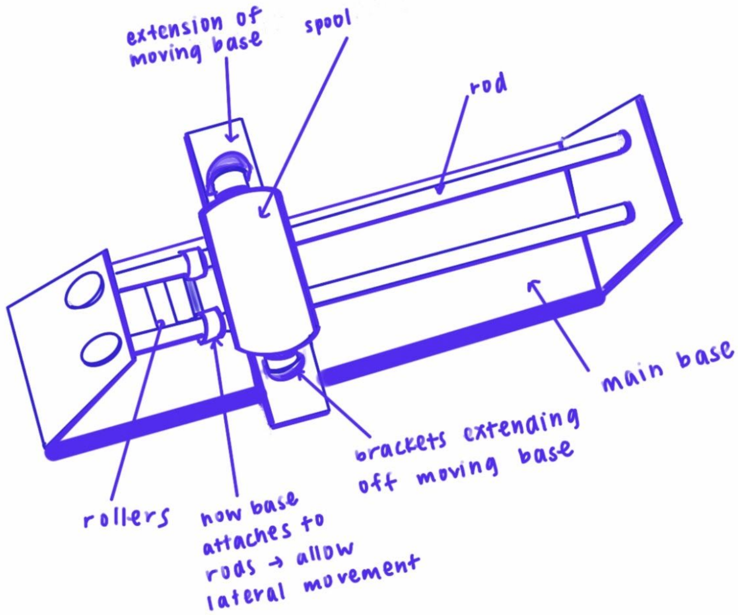


Figure 15: Tile Cutter Variation

CNC Assistance Model

The second variation of our design involves CNC assistance. As shown, the shuttle, which would be attached to the spool that lies on top and rollers that are attached from the bottom, would move in both x and y directions along the rods attached to the rectangular enclosure. This design requires a motorization to facilitate the dispensing. Furthermore, this variation is an extension of the tile cutter design that can move laterally in only one direction along the rods. A rough sketch of this variation is shown below, in Figure 16.

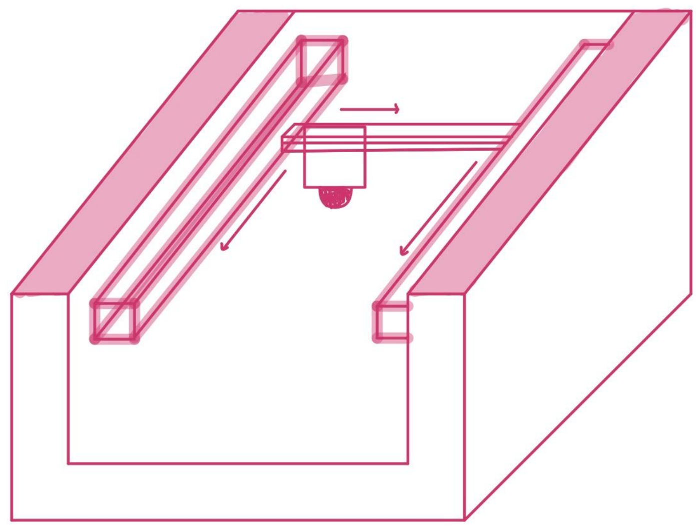


Figure 16: CNC Assistance Variation

Figure 16 does not show the shuttle in detail. Figure 17, below shows what we envision the attachment would look like.

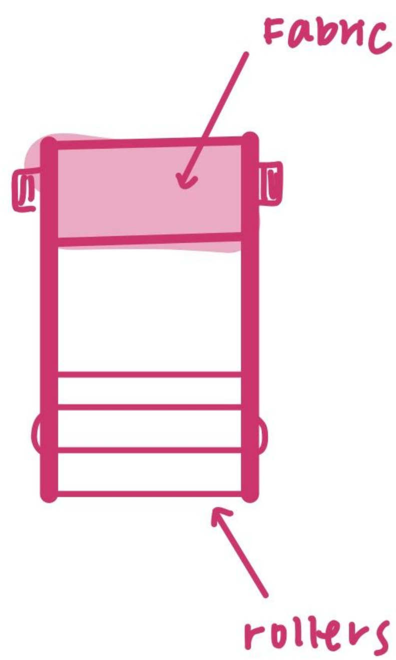


Figure 17: CNC Assistance Attachment

Conveyor Model

The third variation requires a conveyor-like dispensing mechanism with rotary motion powered by a rotary motor. The fabric strips would be wound about the two cylinders of the conveyor and adhere to the biodegradable paper as the conveyor rotates. The biodegradable paper would be attached to a moving platform that moves in the x, y, and z directions as the conveyor dispenses the fabric strip. A diagram of this process is shown below, in Figure 18.

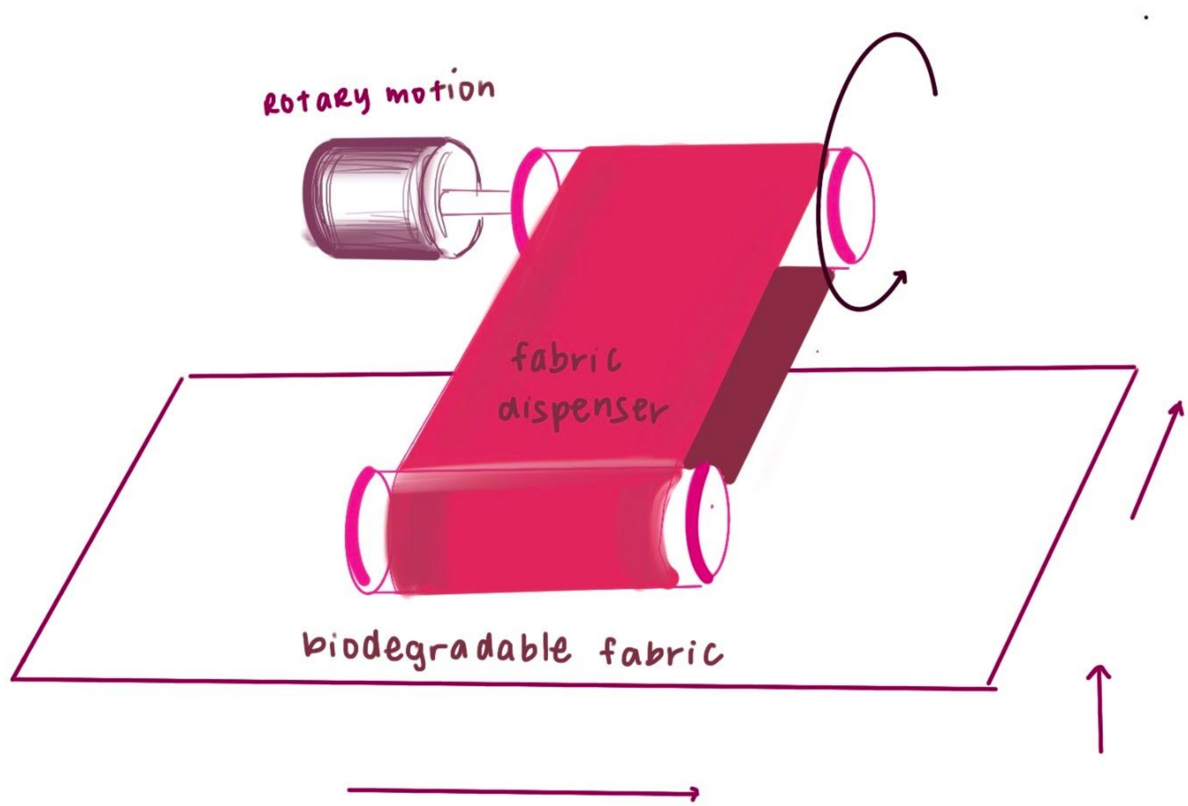


Figure 18: Conveyor Variation

Conveyor + CNC Assistance Model

The fourth variation requires both a conveyor and CNC assistance to facilitate the fabric dispensing. However, unlike the conveyor model described previously, the biodegradable fabric is attached to the conveyor belt and adjusts linearly as the CNC assistance dispenses the fabric onto the biodegradable surface. A diagram of this process is shown below, in Figure 19.

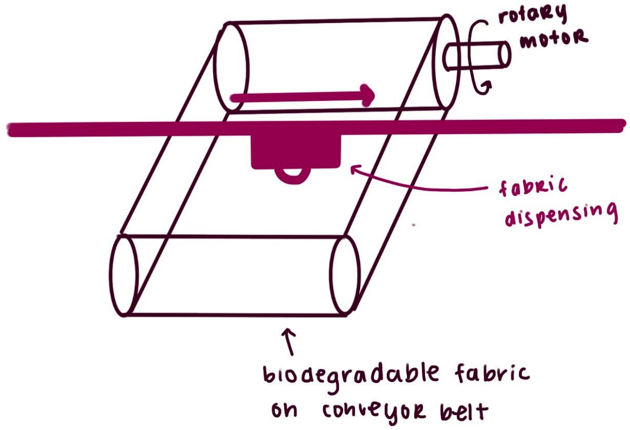


Figure 19: Conveyor Belt + CNC Assistance Model

Handheld Dispenser Model

The fifth variation consists of a spool of fabric and simple handle attachment, similar to a handheld paint roller design. The user would guide the roller using a handle and dispense the strips of fabric onto biodegradable paper. A diagram of this process is shown below in Figure 20.

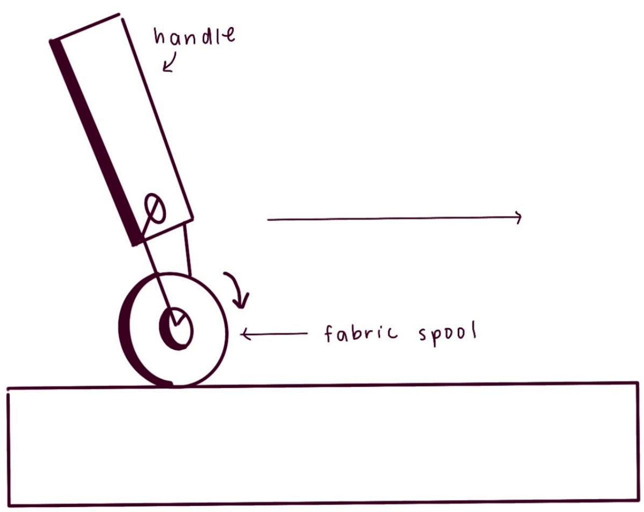


Figure 20: Handheld Dispenser Model

Additional Research

After concluding our independent study, we found other avenues that we agreed would be enriching to explore. Among them, one was to explore how our tool could scale with respect to fabric. We were currently working with woven fabrics, but it is possible to expand to knit structures as well. It would be interesting yet challenging to experiment with other fabrics that tear in different ways. For example a woven fabric will rip along a line, unlike non woven fabrics. The tearing scheme would then influence the design of the cutting tool placed onto the tile cutter. Furthermore, using woven fabrics instead of knit fabrics or cotton would reduce the risk of curling, since woven fabrics stretch only in one direction. So cutting the woven fabric perpendicular to its woven direction would minimize curling.

Another option for additional research would be to explore how the tool moves. Right now, we are constrained to straight, linear movements, but other possibilities include working with a tool that could follow a curve and thus create more intricate patterns. A problem to anticipate would involve the transition from moving in a straight line to moving in a curved direction. It's possible that this wouldn't be a seamless transition, and would have to undergo multiple design iterations.

In the past, Dr. Ruppert-Stroescu experimented with scattering small squares of fabric to create a random pattern. Building a tool that could automatically distribute small squares of fabric evenly onto a specific pattern would be something interesting to explore as well. One of our ideas was to create a rectangular sifter attached to a shaking platform that would cause the small squares of fabric to fall and distribute evenly onto the biodegradable fabric below it. This configuration is shown below, in Figure 21.

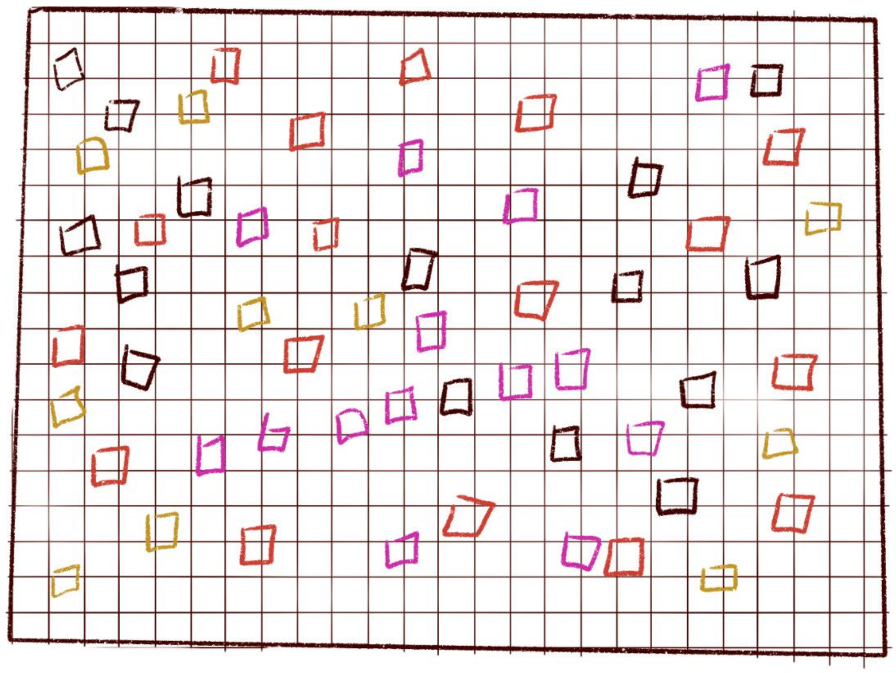


Figure 21: Automatic Fabric Square Shaker Configuration

Since the end goal of Dr. Ruppert-Stroescu's work is to create interesting designs out of upcycled fabric, a great way to make her designs pop would be by adding color variations. An avenue for additional research would involve looking at how colors could change within the spool during the dispensing process. Could the colors slowly fade into different, similar colors within the same spool? Or could multiple fabric colors be wound into the same spool. This would be an interesting problem to look into. Along the lines of fabric, it would also be compelling to look into changing the width of the fabric, and how this would affect existing design parameters.

Discussion & Conclusion

Unfortunately, due to the Covid-19 outbreak, we were not able to fully re-imagine and create a brand new fabric dispenser void of the problems our first MEMS 411 prototype had. However, it was valuable to explore potential new directions to go in. We left off our in person work with buying a tile cutter, studying its design and studying where we wanted to alter and re-imagine the tool. Unfortunately we could not experiment with the CNC, design or the other two designs, but it was valuable to explore these options and visualize mechanically different design concepts for our tile cutter. Producing sketches of alternative design concepts gave us a greater understanding of how we would go about bringing these ideas to life.

References

[1]https://www.homedepot.com/p/Rubi-24-in-Practic-Tile-Cutter-24985/202042337?cm_mmc=ecc-_-THD_PICKUP_REMINDER__V1_M1_CA-_-Product_URL

[2]https://www.inventables.com/technologies/x-carve/fully-loaded?utm_campaign=inventables_pla_generic&gclid=CjwKCAjw4871BRAjEiwAbxXi24-1GNt9n-7vEkiZP4LkT325J_eO9PbHTBAesYxuNHAEoU5GljtQ0BoC9g0QAvD_BwE